

Semiotics, Syntactic and Cartometric Analysis of Müller's Manuscript Maps of the Czech Regions

Vaclav Cada*, Martina Vichrova*

* University of West Bohemia

Abstract. When studying historical maps and their data sets it may be appropriated to compare their content with other period sources. These archive documents often serve for comparative studies with recent state of the territory. Such activities require complete coverage of the territory and georeferencing of those maps and data sets into selected coordinate reference system. Publishing of historical maps by means of modern web technologies offers extraordinary possibilities of opening these historical jewels to general public and use of their information potential into contemporary projects.

The Müller's mapping of Bohemia is indispensably a supreme cartographic work in the Austrian Empire at the beginning of 18th century. Original Müller's map of the Czech regions, compiled between 1712 and 1718, are exceptional from content, technology and historical point of view. They represent the territory within regional administrative boundaries of that time completed by simple informative drawing of topography behind those boundaries in the approximate scale 1: 100 000.

The most important objects in Müller's maps of the Czech regions are settlements differentiated according their types by map symbols. They can be effectively used to maps and map data sets georeferencing. Presented paper provides a detailed semiotics, syntactic and cartometric analysis of planimetric elements of individual manuscript maps of regions and results of accuracy of their georeferencing as well.

Keywords: historical map, manuscript map, Johann Christoph Müller.

1. Introduction

Old maps are a unique testimony to the development of a territory or region in a given historical period. From this perspective, the map set of Müller's manuscript maps of regions with the regional arrangement is without a doubt unrivalled for the 18th century Bohemia. It is an exceptional work in terms of technical or technological aspects, but mainly in terms of its historical importance. In the early 18th century Bohemia there is no comparable map set in the same scale, unified content and level of detail. There are only a few exceptions of rare manuscript maps of some estates available. Müller's manuscript maps of regions came into existence in Bohemia between 1712 and 1718. At first, they showed the original territory within the former regional administrative borders using simplified and often approximate drawings of topographical content in the space beyond the border approximately in a scale 1:100 000 (Cada & Vichrova 2009) . However, the most famous Müller's map of the Bohemia territory *Mappa geographica regni Bohemiae in duodecim circulos divisae cum comitatu Glacensi et districtu Egerano adiunctis circumiacentium regionum partibus conterminis ex accurata totius regni perlustratione et geometrica dimensione omnibus, ut par est, numeris absoluta et ad usum commodum nec non omnia et singula distinctius cognoscenda XXV sectionibus exhibita a Joh. Christoph Müller, S. C. M. capitán, et ingen. A. C. MDCCXX* was created afterwards as a set of 25 map sheets in an approximate scale of 1:132 000. It was a derived map that had its content of original manuscript maps reduced.

2. Müller's Manuscript Maps of Regions

On the basis of the imperial patent issued on 4 May 1712, Johann Christoph Müller was commissioned to mapping of Bohemia. Measurements started in the largest Bohemia region - the "Bechyně" region (*Regni Bohemiae circulus Bechinensis quem mandato Caesareo accurate emensus hac mappa delineatum exhibet I.C. Müller; S.C.M. Ing.*), followed by the regions of "Prácheň" – 1713 (*Mappa chorographica circuli Prachinensis in regno Bohemiae quem mandato caesareo accurate emensus heic delineatum exhibet I.C. Müller; S.C. Majest: Capitan: et Ingen.*), "Plzeň", "Cheb" (1714) and "Loket"¹, "Žatec", "Rakovník"² – 1715 (*Regni Bohemiae circulus Rakonicensis quem mandato caesareo accurate emensus hac mappa delineatum exhibet Joh. Christ. Müller; S.C.M. Capitan: et Ingeniar*), "Litoměřice"

¹ The "Loket" and "Žatec" regions were merged.

² The original name was the "Slaný" region (Pars circuli Satecensis).

(*Regni Bohemiae circulus Litomericensis quem mandato caesareo accurate emensus hac mappa delineatum exhibet J.C. Müller; S.C.M. Capit: et Ing:*), “Hradec Králové” (*Regni Bohemiae circulus Reginohradecensis quem mandato caesareo accurate emensus hac mappa delineatum exhibet Joh:Christoph: Müller; S.C.M. Capitan: et Ingen:*), “Chrudim” (*Regni Bohemiae circulus Chrudimensis quem mandato caesareo accurate emensus hac mappa delineatum exhibet Joh:Christoph: Müller; S.C.M. Capit: et Ingen:*), “Čáslav” (*Regni Bohemiae circulus Czaslaviensis quem mandato caesareo accurate emensus hac mappa delineatum exhibet Joh:Christ: Müller; S.C.M. Capitan: et Ingen:*) and “Kouřim” (*Regni Bohemiae circulus Kaurzimensis quem mandato caesareo accurate emensus hac mappa delineatum exhibet Joh:Christophorus: Müller; S.C.M. Capit: et Ingen:*). The “Čáslav” region map was completed in February 1717; the map of the “Kouřim” region was finished in March 1717. The last mapping was done in the “Boleslav” (*Pars circuli Boleslaviensis*) and “Beroun”³ (*Regni Bohemiae circulus Beraunensis quem mandato caesareo accurate emensus hac mappa delineatum exhibet Joh:Christ: Müller; S.C.M. Capitan. et Ingen:*) regions and the author completed the maps in January 1718. All manuscript maps of the Bohemia regions found so far are stored in the department of art collections of the Museum of Czech Literature in Prague's Strahov. Unfortunately, all attempts to find the manuscript maps of the “Plzeň”, “Boleslav” and “Žatec” regions have failed.

The manuscript maps of the regions became the basis for the manuscript map of Bohemia (*Mappa geographica totius Regni Bohemiae in duodecim circulos noviter divisae cum comitatu Glacensi et distriktu Egerano quam Augustissimo Invictissimoque Principi ac Domino Domino Carolo VI. Romanorum Imperatori semper augusto Germaniae Hispaniarum Hungariae Bohemiae Regi propagatori rei christianae publicaeque felicitatis optimo maximo summa cum pietate dedicat Maiestatus ejus infimus servus Joh: Christoph: Müller, S. C. M. Capitan: et Ingen: Author*) that was dedicated to Charles VI (Cada & Vichrova 2009). After regional governors had made their revisions of the maps, which significantly delayed and negatively affected the content quality of the maps and their timely delivery, Müller created handwritten templates for a copperplate map of Bohemia on 25 map sheets with one overview sheet and handed them over to a Czech court officer, *Referendarius v. Deblin*.

³ The “Beroun” region was established by merging the original “Podbrdy” (*Pars Circulo Podbrdensis*) and “Vltava” (*Pars Circulo Moldaviensis*) regions.

3. Planimetric Content of Müller's Manuscript Maps of Regions

The planimetry of Müller's manuscript maps was probably based on measured distances (Paldus 1907) and directions (rather magnetic bearings). The distance measurement was carried out using **Instrumentum viatorium**, a device attached to a travelling carriage. The measured distance was functionally dependent on the number of rotations and circumference of a wheel. Only the distances on the earth's topographic surface were measured this way, not the horizontal distances, direct or transferred to the projection plane. Significant differences in measured lengths in the field (travel distance) and straight lengths required for the map construction (cartometric length) were subsequently computed by approximate reduction of lengths obtained using viatorium by ten percent.

Determining the direction ratios was based on the magnetic bearing measurements (see available topographer's surveying instruments). Müller undoubtedly used compass measurements for more accurate and detailed mapping, such as the mapping of the *Ore Mountains boundaries*. His use of the compass measurements is also indicated by drawings of compass roses. On the manuscript map of the "Prácheň" region directly in the center of the compass rose on both sides of the magnetic declination needle is marked its value (*Vienn 1708 Declinat 10°*). The magnetic declination values measured on raster equivalents of Müller's manuscript maps are shown in (Cada & Vichrova 2009) and further details on the issue of measurement in (Cada 2010).

However, the possibility of all the constructional lengths being measured is not real, considering the progress of mapping and the fact that Müller was simultaneously working on several orders in different regions at the same time. From the 17th century on, detailed postal lexicons and travel itineraries with information about distances between locations were regularly published. The cooperation with the local (land, regional) administration was also very important. It is documented by Müller's personal correspondence with the court administration; and therefore we can hypothesize that all these resources were used and that the actual "measurement" was limited to a minimum.

It should also be noted that with regard to the scope of work and all organizational and managerial activities, Müller certainly did not work alone, but rather with a large team of support staff. Literary sources also provide

names of some of his collaborators. For instance, *Fabian Svoboda*⁴ is mentioned in connection with measurements in southern Bohemia. This assumption can be further supported by a detailed semiotic analysis of map symbols on the manuscript maps of the individual regions, but also by a graphology analysis of individual map legends.

The basic planimetric content of Müller's manuscript maps mainly showed **settlements** divided by type into fortified towns (the town plan view and fortifications with block buildings inside the walls were schematically shown), towns without fortification, small towns with markets, small towns with chateaus, villages with churches and a château, villages with a château, villages with churches, villages without churches and vanished villages, see (Semotanová 2001). Also castles, chateaus, lordly and knight manors can be classified as **residential buildings**. The settlements are the most important planimetric objects well applicable to the localization of the individual maps.

Other elements of the basic planimetry are the royal roads, rivers and regional (land) border. This planimetric content is shown only schematically and is not suitable for localization of the manuscript maps of the regions. The roads represented only provide an approximate interconnection overview between the most important settlements without the ambition to capture the complexity of the already existing road network. The situation was similar when it comes to streams and pond systems. In comparison with the accuracy of the settlements, much larger deviations, not only in the position, but especially in the geometric shape of the objects occurred.

The thematic planimetric content comprised **ecclesiastical objects** (free-standing churches, monasteries) and **economic objects** (ponds, inns, water and wind mills, bridges, and post offices, iron ore mines, gold mines, silver mines and tin mines).

On Müller's manuscript maps of regions one can also see objects with no map symbols, differentiated only by letterings such as sheep pens (*ovile*), hermitages (*eremitoria*), spas (*thermae* or *balneum*), glass works (*officinae vitrariae* nebo *Glasshütten*) or gamekeeper's lodges (*Jägerhaus*), see table 1. These objects are charted using only the map symbols in the Müller's

⁴ Fabian Svoboda was christened in the village of "Lišov" near "České Budějovice" on 19 January 1688. He worked as a clerk for Franz Adam Prince of Schwarzenberg in Vienna who also financed his studies under von Steinhausen, an Imperial engineer. In 1710, he took part in measurements in Moravia of which J. Ch. Müller was in charge. In 1711, Svoboda worked for Prince Schwarzenberg as a helper of surveyor Maximilian Stransky in "Třeboň". In 1712 he participated in another of Müller's measurements in southern Bohemia (Petrik 1941).

Maps of Bohemia map set *Mappa geographica regni Bohemiae in duodecim circulos divisae cum comitatu Glacensi....*


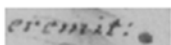
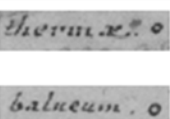
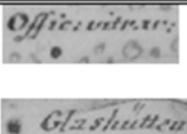
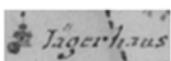
Sheep pen	Hermitage	Spa	Glass Works	Gamekeeper's lodge
				

Table 1. Objects on the Müller's maps of regions without their own map symbol.

The lettering forms a well-marked part of the content of the manuscript maps of the regions. It is most frequently used for settlement, hamlet and court names. Some settlements (see, for example, the “Bechyně” and “Prácheň” regions) have the German lettering accompanied by their Czech names preceded by the letter B. Significant is not only the description of the provinces and regions of the administrative division before the territorial reform in 1714, but also lettering of the border ridge of hills and mountain ranges. Also some streams (e.g. *Elb.fl.*), including springs and major regional localities such as *Ribenzahls Luft garden* (see Figure 1) are labelled. The same was applied to several ponds in the pond basin of the “Bechyně” region in southern Bohemia.



Figure 1. Sample of manuscript map of “Hradec Králové” region (oriented towards the Northeast).

Furthermore, accompanied by the letterings are also the historical Golden Path (*der goldene Steig*) in the “Prácheň” region or individual small church buildings such as small churches and chapels. They bear names of the Saints who they were dedicated to. However, the individual object lettering is not systematic throughout the whole territory of the region. It varies substantially in the individual maps.

The type of terrain is shown using so called *ichnograms* (prints of different sized schematic symbols), which are grouped into areas and provide a very

good overview of the vegetation, especially in forest complexes (see detail in Figure 2). The ichnogram design differs in the individual regional maps. In later maps, the effort to simplify the symbol is evident. The maps of the “Bechyně” and “Prácheň” regions use more complex symbols evoking broadleaved forest or shrubbery in brown; in the “Rakovník” region map we can see simple oval shaped gray dots. The “Litoměřice” region map also depicts wetland and vineyard areas. The used map symbols are shown in Figure 3.



Figure 2. Sample of a manuscript map of the “Beroun” region with the forested Brdy Mountains.



Figure 3. Wetland and vineyard areal symbols on manuscript map of “Litoměřice” region.

Müller's manuscript maps of regions are equipped with a map graticule on the map frames. The map sheets of the “Bechyně”, “Prácheň”, “Rakovník”, “Litoměřice” and “Kouřim” regions have the map graticule drawn by one arc minute (every fifth minute labelled). The map sheets of the “Hradec Králové”, “Chrudim”, “Čáslav” and “Beroun” regions have the graticule drawn by five arc minutes with every tenth minute being labelled. On the map sheet of region “Bechyně” is the five minute interval graticule drawn inside the map sheet as well with its columns labelled A-S eastwards and layers a-m from north to south. The graticule plotting is unfortunately not very accurate. There are serious errors in the division of the map frame (see

Figure 4), one can say that the graticule plot is only schematic and the geographic coordinates were taken from other sources.

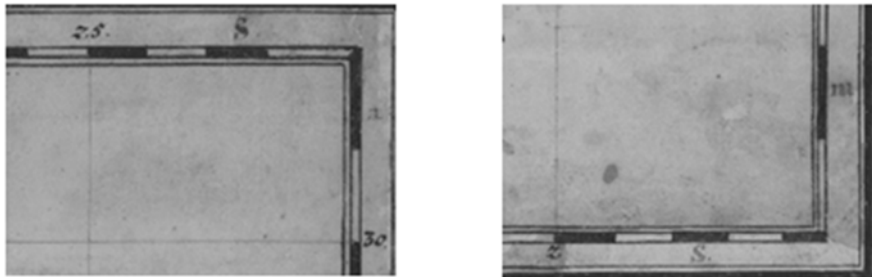


Figure 4. North-eastern and south-eastern corner of “Bechyně” region map sheet with incorrect graticule scale.

4. Altimetric Content of Müller's Manuscript Maps of Regions

The so called “small hills method” (Pravda 2005) supplemented by the application of diluted drawing ink on the north-east slopes was used to depict the elevation on Müller's manuscript maps. The impression of the elevation depiction is intensified by the elements of plant cover. In various significant terrain formations, a clear effort to preserve their characteristic shape for easier map reading is obvious. Some important peaks are also lettered (see Figure 5).



Figure 5. Sample of “Rakovník” region manuscript map with the mountain “Říp” in the middle.

On the contrary, there are provable examples of several terrain formations where only approximate elevation depiction, even without measuring of relative heights, can be documented. The mountain “Milešovka” is depicted at the bottom of Figure 6 (832 meters above sea level, the highest peak of the “České Středohoří” above the village of *Milischau*). It is optically smaller than the neighboring “Kletečná Mountain” (706 meters above sea level - the

village of *Kletschen*). It is probably the author's mistake that was made during the elevation depiction process.



Figure 6. The mountains “Kletečná” versus “Milešovka” on Müller's manuscript map of “Litoměřice” region.

5. Localization of Müller's Manuscript Maps of Regions

With regard to the specific content and the method of treatment of Müller's manuscript maps of regions, an appropriate method of localizing this map set into the national reference coordinate system of the Uniform Trigonometric Cadastral Network (S-JTSK) was chosen so as not to disrupt the topographic content of the maps. A cartometric analysis of the maps showed that they were not based on any reference basics derived from any geodetic or astronomical measurements. It is also difficult to prove the properties of cartographic fundamental parameters (e.g. the cartographic projection, the choice of parameters of the projection surface and the coordinate system).

The accuracy of the localization is dependent not only on the quality and accuracy of the original map, but also on the content and type of the map. It is necessary to take into account what objects were charted first and what objects followed, what was the decision on the planimetry generalization and which elements were drawn only approximately or schematically.

The raster equivalents of the manuscript maps of the regions were acquired with the consent of the management of the department of art collections and the management of the Museum of Czech Literature in Prague's Strahov in the TIFF format (*Tagged Image File Format* - true colour, 400dpi) using the *Contex CRYSTAL G600* scanner. They were further processed in the Department of geomatics, of the Faculty of Applied Sciences at the University of West Bohemia in Pilsen. Some of the larger map sheets were cut to irregular-sized map parts according to the size of a particular region. The “Bechyně” region originally comprised fifteen separate parts,

the largest “Hradec Králové” region was cut to twenty-three map parts, the “Prácheň”, “Litoměřice”, “Kouřim” regions had nine parts, the “Rakovník”, “Chrudim” and “Čáslav” regions had six parts and the “Beroun” region consisted of four separate parts. The backs of the manuscript maps of the regions archived this way were pasted with cardboard mats during restoration works in the 1980's. The large map sheets, such as the ones of the “Bechyně” and “Hradec Králové” regions, are placed on two separate cardboard mats attached to each other with a book binding cloth. That is why it was necessary to reconstruct the raster equivalents of the map sheets to restore them to their original state prior to the cutting.



Figure 7. Matching of adjacent map sheets of “Hradec Králové” region before and after restoration.

The individual map parts were therefore attached to each other using congruent transformation, by matching identical points on the edges of the individual map sheets. The endpoints of linear elements (roads, streams) represented on the neighboring parts, possibly another noticeable drawing on the common edges of the individual parts were chosen as the identical points. Because there were differences of the individual parts caused by shrinking, the Jung nonresidual transformation on identical points using software *Kokeš* system environment was used.

The settlement cartometric coordinates were read on such reconstructed map sheets according to the settlement categories as the most noticeable and complex objects of Müller's manuscript map planimetry. The fortified towns, shown by a schematic layout within the town walls, can have the definition point placed in a quite clearly identifiable space, such as the cen-

tre of the square, cathedral, church, town hall, or an intersection of major roads, etc. Other settlement categories are represented on the manuscript maps by pictorial symbols with their definition point of a circular shape marked (see, for example, Figure 7). The cartometric coordinates of these settlement types were referenced to the center of the circular symbol.

There are authors who suggest that Müller's maps were created using the results of astronomical measurements of selected objects. These assumptions were the reason for creating a hypothesis stating that if the astronomical measurements were really performed during the mapping (for instance for important settlements), this group of settlements would show better results in their position. This hypothesis, however, did not prove tenable and the set of the cartometric coordinates was analysed as homogeneous.

6. Conclusion

The cartometric and semiotic analysis of Müller's manuscript maps from 1712 to 1718 unequivocally confirmed their uniqueness for research purposes and regional research on the level of administrative regions of that time. The final localization of the map set into the reference JTSK coordinate system provides such great results that it is possible to study the evolution of the landscape not only from the time point of view, but also in regard to the spatial development of the territory. A detailed analysis of the topographic content was performed and the frequency and types of settlements were statistically evaluated.

Briefly described is also a database of settlements (DBS) which was created to localize the map sets where the geodetic and cartographic fundamental parameters cannot be used. DBS is also used for the analysis of the development of individual settlements over time and of the toponymy trends in the region. Since all information about the settlements is database-stored and linked to the current statistical units, it is possible to perform all analyses in large territories very operatively. Data stored in DBS are used for search and display functions of the web services of the map portal that is being created.

The cluster analysis method was used for the localization of Müller's manuscript maps. It enabled the analysis and elimination of areas affected by systematic errors during mapping. Based on the performed analyses it is possible to state that the different categories (types) of settlements are represented in Müller's manuscript maps with comparable accuracy. The positional accuracy depends on the space of individual region.

Close attention was also paid to the remaining content of the manuscript maps and it is clear that these objects (river system, roads, boundaries of territorial units, hypsometry) were represented in a highly generalized way, almost schematically, in Müller's manuscript maps. It was also proven beyond any doubt that even the graticule plotting is very approximate and cannot be used for accurate map localization. For this reason, it is also difficult to verify the characteristics of the cartographic projection.

Despite these partial shortcomings and limits of the analysed map set of Müller's manuscript maps, this resource can be decidedly recommended to other researchers for its unique historical content, its detail and comprehensiveness. The cartographic quality of the maps and their overall aesthetic qualities also deserve attention. However, remarkable is also the overall project of creating this state map set of the Austrian Empire in the early 18th century and the absolutely crucial role of Johann Christoph Müller. This exhausting mapping of Bohemia was also his last...

7. Acknowledgement

This contribution was supported by the European Regional Development Fund (ERDF), project "NTIS - New Technologies for Information Society", European Centre of Excellence, CZ.1.05/1.1.00/02.0090.

8. References

- Cada V (2010) Kartometrická kvalita Müllerovy mapy Čech aneb vychází Müllerovy mapy Čech z astronomicky určených zeměpisných souřadnic? *Geodetický a kartografický obzor* 2010: 14-20.
- Cada V, Vichrova M (2009) Rukopisné mapy Čech J. Ch. Müllera. *Kartografické listy* 200: 21-30.
- Paldus J (1907) Johann Christoph Müller. Ein Beitrag zur Geschichte vaterländischer Kartographie. Josef Roller&Comp., Vienna.
- Petrík J (1941) Fabian Svoboda. *Zeměměřický obzor*, Volume II/XXIX, Czech Association of Engineers in Prague.
- Pravda J (2005) Georeliéf na mapách. *Geodetický a kartografický obzor*, Volume 51/93, number 8: 173-179.
- Semotánová E (2001) "Tematické" legendy listových map českých zemí ve století Jana Kryštofa Müllera. *Historická geografie* 31: 241 – 275. Historický ústav AV ČR, Prague.